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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

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PROGRAMME

FOR THE

PASADENA MEETING

AT

CALIFORNIA INSTITUTE OF TECHNOLOGY

PASADENA, CALIFORNIA

DECEMBER 27, 1943

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PASADENA MEETING, DECEMBER 27, 1943

THE **258th meeting of the American Physical Society** will be held at the California Institute of Technology, Pasadena, California, on Monday, December 27, 1943. There will be two sessions, starting at 9:30 A.M. and 1:30 P.M. The morning session will be held in Room 155, Arms Laboratory (about 100 yards west of the Norman Bridge Laboratory), and the afternoon session in the usual Room 201, Norman Bridge Laboratory. Following six contributed papers at the morning session, two invited papers will be given by Linus Pauling and F. Zwicky. The afternoon session will open with invited papers by Alexander Goetz and O. Beeck, and these will be followed by the remainder of the contributed papers.

Luncheon will be served at the Athenaeum and it is hoped that those attending the scientific sessions will take this opportunity to discuss our mutual problems and interests. The Constance Hotel, which is within walking distance of the Norman Bridge Laboratory, is available for overnight accommodations ($3 single; $4 double with double bed, $5 with twin beds; all rooms with bath), but reservations should be made several days in advance of the meeting.

General Rules Relating to Papers

By vote of the Society on December 27, 1940, no paper may be accepted for presentation at any meeting of the Society unless the title and an abstract of the paper are delivered to the office of the American Physical Society not later than the closing date stated in the printed call for the meeting.

The time allowed for the oral presentation of a contributed paper is ten minutes at most.

When two or more papers are contributed by the same member, all but one are placed on the "supplementary programme." (A paper by two or more members is credited to the one first named in its title.) For each paper on this programme the Secretary indicates a session at which it may be presented. The presiding officer at this session may call for it when the other papers are completed, may require that it be given in shortened form, or may read it by title.

Titles and abstracts of the papers to be presented are given in the following pages. Proofs of these abstracts have not been submitted to the authors. After submission of proof the abstracts will be published in an early number of *The Physical Review.*

R. T. Birge,
Local Secretary for the Pacific Coast,
University of California
Berkeley, California

PROGRAMME

MONDAY MORNING AT 9:30 O'CLOCK

ROOM 155, ARMS LABORATORY

Contributed Papers

1. Analysis of a Multivibrator. S. C. SNOWDEN, *California Institute of Technology (Introduced by W. H. Pickering).*—A theoretical analysis of the action of a fundamental multivibrator has been undertaken along the lines of Van der Pol's analysis.[1] A more exact approximation to the transfer characteristic has been used and an exact solution of the equation has been found in the case where the shunt capacities of the tubes can be neglected. In this approximation the period of oscillation has been calculated and checked experimentally. The limiting frequency of oscillation in which the wave form is sinusoidal can be calculated as in Van der Pol's case. The results agree with experiment within three percent.

[1] B. Van der Pol, Phil. Mag. **2**, 978, 1926.

2. A Voltage Regulator for High Voltages. W. H. PICKERING AND S. C. SNOWDEN, *California Institute of Technology.*—The standard degenerative voltage regulator circuit usually becomes difficult to use at voltages above a few kilovolts. This is particularly true in applications where the positive terminal is grounded. The new circuit avoids the difficulties by using a radiofrequency signal modulated by the variations in output voltage to transmit these variations across the potential difference to a tube in series with the high potential bus. The voltage limitations are accordingly removed and furthermore, either terminal of the output may be at ground potential. The sensitivity of the regulator depends as usual upon the total effective amplification of the circuit. Long-time stability depends on the stability of the amplitude or frequency of the radiofrequency signal.

3. A Light Source for the Primary Standard of Wave-Length. CHAO-WANG HSUEH, *California Institute of Technology.*—Despite some objections,[1] the red Cd line, 6438.4696A, still remains the primary standard of wavelength for lack of a satisfactory substitute. In our laboratory a light source of the Michelson type has been constructed for this standard line. The interferometer spectrograms show that the line is as narrow as, or even narrower than, that emitted from the Osira Cd lamp (Adam Hilger), and is very intense. Our lamp produces a satisfactory spectrogram with only thirty minutes' exposure. Under the same conditions the Osira lamp gives a lighter spectrogram with six hours' exposure. Furthermore, the intensity of our lamp can be varied over a wide range by changing the primary voltage of the transformer. The effective light-emitting area is 50×2.5 mm^2 which, if necessary, can be enlarged by means of a magnifying lens. The Doppler effect should disappear because the light is observed in a direction perpendicular to that of the current. Owing to the high intensity, simultaneous observation of the standard line and of lines from another source is possible either by using a half-reflecting mirror, or by placing the latter source in front of the spectrograph slit. These features eliminate the important objections against a light source for the standard Cd line.

[1] W. F. Meggers, Rev. Mod. Phys. **14**, 59 (1942).

4. On the Elastic Vibrations of Cylindric Shells. PAUL S. EPSTEIN, *California Institute of Technology.*—The problem of the characteristic oscillations of curved shells with the usual border conditions (clamped edges and free edges) has remained hitherto unsolved. A method of treating elastic shells given by the author[1] permits of obtaining the solution, which was worked out for shells having the shape of circular cylinders. The result is particularly simple in the case of very thin shells. The three types of border conditions, namely, clamped edges, free edges, and supported edges, lead to the same characteristic frequencies. But the character of the oscillations, as evidenced by the distribution of the nodal lines, is not the same for clamped as for free edges.

[1] Paul S. Epstein, J. Math. and Phys. **21**, 198 (1942).

5. Forbidden Lines of Ca II in a Stellar Spectrum. PAUL W. MERRILL, *Mount Wilson Observatory.*—A low dispersion spectrogram of the fourth-magnitude star υ Sagittarii, type cApe, obtained by H. F. Weaver at Mount Wilson in 1942, showed the $^2S-{}^2P$ triplet of Ca II, λλ8698, 8542, 8662 in emission. Spectrograms with higher dispersion (21A/mm), obtained by the writer in 1943, showed in addition the forbidden doublet $^2S-{}^2D$, λ7291.47, λ7323.88. No previous observations of these forbidden lines either in the laboratory or in astronomical sources seem to be on record. The star is a spectroscopic binary of period 138 days whose brighter component (the only one observed) has a range in radial velocity of 96 km/sec according to an orbit computed in 1914 by R. E. Wilson from the measured displacements of the dark lines. The bright lines of H and Ca II indicate little if any change in velocity. Hence they probably originate not in either component of the binary pair but in an enveloping gaseous cloud.

6. Further Studies on the Least Penetrating Component of the Incoming Cosmic Rays. R. A. MILLIKAN, H. V. NEHER, AND W. H. PICKERING, *California Institute of Technology.*—Although the war has prevented us from making such convincing tests on the existence of helium annihilation rays as we reported earlier[1] on silicon, oxygen, nitrogen, and carbon annihilation rays, we are able to present herewith heretofore-unpublished evidence obtained with the aid of high altitude electroscope measurements for the existence of approximately the energy to be computed from the helium annihilation hypothesis.

[1] Millikan, Neher, and Pickering, Phys. Rev. **63**, 234 (1943).

Invited Papers

Specificity of Intermolecular Interaction. LINUS PAULING, *California Institute of Technology.*

The Morphology of Nebulae and Clusters of Nebulae. FRITZ ZWICKY, *California Institute of Technology.*

MONDAY AFTERNOON AT 1:30 O'CLOCK

Room 201, Norman Bridge Laboratory

Invited Papers

The Problem of Rendering Sea Water Potable. ALEXANDER GOETZ (in collaboration with S. J. BROADWELL AND D. C. WARNER), *California Institute of Technology.*

Physical Methods in Hydrocarbon Research. OTTO BEECK, *Shell Development Company, Emeryville, California.*

Contributed Papers

7. The Average Specific Ionization of the Mesotrons 100 Ft. Underground. WAYNE E. HAZEN, *University of California.*—Cloud-chamber photographs have been taken in a tunnel with 100 ft. of rock overhead. The chamber was operated in such a way that the ionization of cosmic-ray mesotrons could be obtained from the number of drops that condensed on positive ions. No magnetic field was used. A preliminary survey of the photographs has given a value of 60 ion pairs per cm in air at N.T.P. for ionization events in which less than 2500 ev of energy was lost by the cosmic ray per primary ionization (in other words: clusters of more than 80 drops were omitted). It was found that approximately 10 percent of the energy loss of a mesotron is attributable to collisions in which between 1200 and 2500 ev is lost to an electron. There have been two determinations of the specific ionization of cosmic rays at sea level in this laboratory: one resulted in a value of 56, the other in a value of 46 ion pairs per cm of air at N.T.P. One expects an increase in the average specific ionization with depth since the average energy increases with depth. A rough calculation indicates that one might expect a 10 percent increase in the average specific ionization at a depth of 100 ft.

8. Friction of Binary Alloys with Thin Film Lubrication. S. KYROPOULOS, *California Institute of Technology.*—An apparatus originally designed for investigation of lubricant characteristics[1] was converted to measure over-temperatures of alloys rubbing against steel. Equilibrium temperature is usually reached in one-half hour; accuracy ±0.3°C. As a basis of bearing alloys, first specimens were investigated covering the phase diagram Pb-Sb. Allowing for irregularities due to the crystallization process and solid solubility, the hardness of these alloys follows substantially a linear relationship. The overtemperature-composition curve is from 0–20 percent Sb almost its mirror image. From 20–100 percent Sb the curve goes through a minimum around 40 percent Sb, thus being substantially convex to the composition axis. This phenomenon may be interpreted as an effect of the differential thermal expansion of the duplex structure, resulting in a shift toward more fluid lubrication. Apparatus and procedure followed permit study of precipitation hardening effects on friction and some insight into basic contributing factors such as plasticity and shearing off of particles and their reaction on various lubricants.

[1] S. Kyropoulos, Refiner **18**, 273, 320, 399 (1939); **19**, 85 (1940).

9. Present Status of Spectroscopic Methods of Analysis. M. F. HASLER, *Applied Research Laboratories, Glendale, California.*—Today's versions of many instruments usually considered as tools of the physicist but now being used

almost exclusively for the analysis of materials by the spectroscopic method, are described. The scope of the spectroscopic method is discussed as is its present day position. The future possibilities opened up by direct reading instruments, made practical by recent advances in vacuum-tube design, are considered.

10. Frequency-Band Character of Shock Vibrations. S. LEROY BROWN, *University of Texas.*—A so-called shock vibration is one with a fundamental frequency but the amplitude is zero for more than half the cycle. Analysis of specific wave forms shows that, though the intensity of the harmonics decreases with frequency, there are bands of relatively greater intensity. For example a square-top wave of height h for a quarter of a cycle (height zero for three-quarters of the cycle) gives $1.4h/\pi$, $2h/2\pi$, $1.4h/3\pi$, 0, $1.4h/5\pi$, $2h/6\pi$, $1.4h/7\pi$, 0, $1.4h/9\pi$, $2h/10\pi$, $1.4h/11\pi$, 0, $1.4h/13\pi$, $2h/14\pi$, etc., for the amplitudes of the harmonics. A vibration of 20 cycles per second, the wave form of which is half a sine curve for one-twentieth of the cycle (zero for nineteen-twentieths of the cycle), gives weak harmonics around 600 cycles per second, comparatively strong harmonics around 800 cycles per second, weak harmonics around 1000 cycles per second, etc. If the half-sine curve occupies a small fraction of a cycle, the amplitudes of the lower harmonics decrease very slightly with frequency.

11. A High Sensitivity String Galvanometer. ARTHUR E. LOCKENVITZ, *University of Texas* (*Introduced by S. Leroy Brown*).—A string galvanometer is described having a sensitivity as high as 10^{-9} ampere per scale division and at this sensitivity a period of less than a tenth of a second. A new method of keeping the string under constant tension is used. A platinum wire 0.001 mm in diameter and about 7 cm long is fastened at the ends to rigid terminals but in such a way that the wire is very slack. Near one end of this platinum wire a second wire of the same diameter is tied so that it is at right angles to the first and its ends are fastened to fixed terminals like the first. This string assembly is in a magnetic field so that both wires are at right angles to the field. An auxiliary current of a few milliamperes produces a force action in the second wire which causes the main string to be held under any desired constant tension. By means of a simple switching arrangement, the sensitivity and period can be varied over wide limits. The instrument is extremely stable and rigid.

12. The Explosion of Ether-Air Mixtures by Electrical Sparks. A. M. ZAREM, *California Institute of Technology* (*Introduced by R. A. Millikan*).—Sparks were passed between spherical and pointed electrodes immersed in a combustible ether-air mixture. It was found that the energy in a spark required to explode the mixture decreased as the sparking potential was increased. At 4000 volts, a non-oscillatory spark current as low as 400 microamperes (peak value) exploded the mixture. At 2000 volts the peak current required for explosion was of the order of amperes. The shape of the electrodes affected the minimum energy necessary for explosion. No explosions were obtained using a prolonged corona discharge from a Wimshurst machine with voltages ranging up to 35,000 volts. Explosions were obtained, however, when a spark was passed between either pointed or spherical electrodes at 4000 volts. In many cases the peak current in the spark which caused explosion at the lower voltage was not as great as the corona discharge current.

13. Excitation of Electromagnetic Waves in Wave-Guides and Cavities. JOHN MILES, *California Institute of Technology* (*Introduced by R. A. Millikan*).—The impedance of thin transverse wires in rectangular wave-guides and cavities has been evaluated by application of the vector potential. Both the resistive and the reactive components have been obtained, and one is thus enabled to place a driving or receiving element so as to match a given source or load for the maximum power transfer. The problem of short circuiting wires has also been calculated. The solution of the analogous problems in a circular wave-guide is indicated.

14. X-Ray Inspection of Spotwelds in Aluminum Alloys. R. C. MCMASTER, *California Institute of Technology* (*Introduced by R. A. Millikan*).—This paper presents preliminary results of a study whose purpose is to develop practical industrial methods for the non-destructive testing of spotwelds in aluminum alloys. Procedures for x-ray inspection using industrial equipment have been developed, and correlations have been obtained between radiographs of spotwelds and spotweld structure, quality and strength. The scope and limitations of the method are indicated through the presentation of results of tests on thousands of industrially-made spotwelds. The results of preliminary tests employing fluoroscopic and special x-ray equipment are outlined.

15. Sparking Potentials in Air in a Plane Parallel Gap at and below Atmospheric Pressure. LEON H. FISHER, *University of California.*—The streamer theory of the electric spark developed by Loeb and Meek[1] has indicated the importance of sparking potential studies in air at half an atmosphere pressure. Sparking potentials in a plane parallel gap in air have been measured as a function of plate distance and pressure. Below atmospheric pressure, the sparking potential curve as a function of distance at constant pressure shows a peculiar leveling off at large plate distances. This effect increases with decreasing pressure, and has been shown to be due to the effect of the metal walls of the large chamber used (50-cm diameter). Significant measurements at low pressures will require the use of larger chambers than have been used previously. The walls of the chamber do not influence the measurements at atmospheric pressure, and the sparking potential for a one-centimeter gap at atmospheric pressure at 22°C is 30.1 kv. The data at atmospheric pressure, when analyzed either by Townsend's sparking equation or by Meek's equation, are more self consistent than any other available data. Water vapor causes a small but definite scattering in the potentials at which sparks occur.

[1] L. B. Loeb and J. M. Meek, *The Mechanism of the Electric Spark* (Stanford University Press, 1941).